Experiences of an Air Bubble Rise in the HANARO Reactor Pool

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1. Introduction

HANARO is an open-tank-in-pool type research reactor operated by KAERI. Its thermal power is 30 MW and the core is immersed in the reactor pool whose depth is about 12 m. It also has a service pool used for services such as an irradiation target change and the visual inspection of targets or fuel, and a spent fuel storage pool. The arrangement of these pools of HANARO is as in Fig. 1[1]. During a normal operation, the reactor pool and the service pool is connected

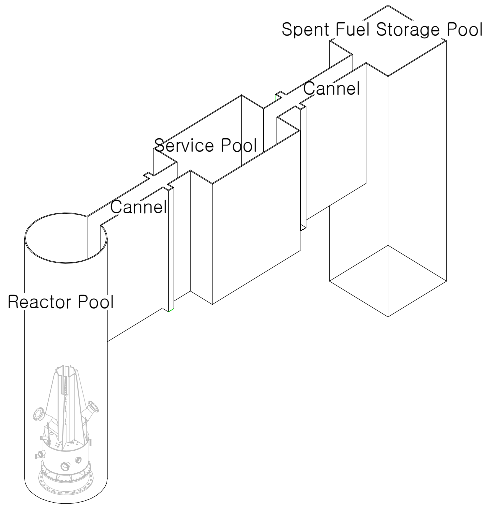

Figure. 1 Pool Arrangement in HANARO

There are several paths through which the air could permeate into the primary cooling system and the pool water. If air bubbles which have radioactive isotopes, rise through the pool, the radiation level at the pool surface may increase. This is not desirable for a stable and safe operation. This paper describes the experiences of an air bubble rise through the pool and the counter measures undertaken to prevent a bubble rise.

2. Experiences of Bubble Rise in the Pool

The air could permeate into the pool and the primary cooling system due to a natural phenomena or the failure of components for a reactor cooling or a target irradiation.

2.1 Bubble Rise due to the Change of Water Temperature

The solubility of air in water is a function of the temperature and pressure. Figure 2 shows the maximum amount of soluble air in the HANARO pool depending on the pool water temperature. For this figure, it was assumed that the water was saturated with air and that its pressure was 1 bar. As the volume of the water in the reactor pool and the service pool is about 330 m^3 including the water in the primary cooling system, the amount air that could exist in the pool is very large. For an inspection of a reactor component during a shutdown, we should discharge all the fuels in the core and decrease the reactor pool temperature. Therefore more air may permeate into the pool water. When the pool temperature increases due to a loading of the fuel and its operation, the air dissolved in the water comes out of the water due to a change of solubility and air bubbles can rise through the pool water. To prevent this phenomenon, the pool water is heated by running the primary cooling pump before a reactor start-up following a shutdown period.

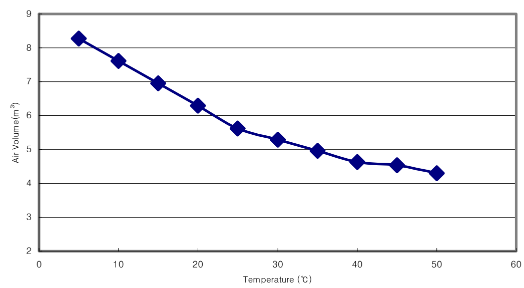

Figure 2. The Maximum Amount of Air Soluble in the Primary Cooling System, the Reactor and the Service Pool of HANARO

2.2 Failure of the Pump Seals

The primary cooling system of HANARO has two pumps and the purification system attached to the primary cooling system also has a pump. When there is a seal leak in these pumps, the air permeates into the primary cooling system and the reactor pool. Then, the air bubble rises in the pool. To prevent this, a regular inspection is important

2.3 Welding Failure for In-pool Components Having Cavities

There are many irradiation holes in the reflector vessel surrounding the reactor core. They can be used for a radio-isotope production or for an installation of irradiation facilities. Some of them were found to be inefficient and were not used. To increase the neutron flux in the holes used for the irradiation of targets, it was decided to insert plugs into the unused hole. The plugs having a cavity were made of Al and passed the x-ray inspection before the installation. Later, it was found that air bubbles rose from a plug due to a welding failure. As a measure to prevent the reoccurrence of this, a neutron radiography inspection is routinely performed for the in-pool components having cavities before a use. Figure 3 is an example of detecting the water inside an irradiation rig made of Al[2]. The brighter region at the center represents the water permeated into the cavity through a welding failure.

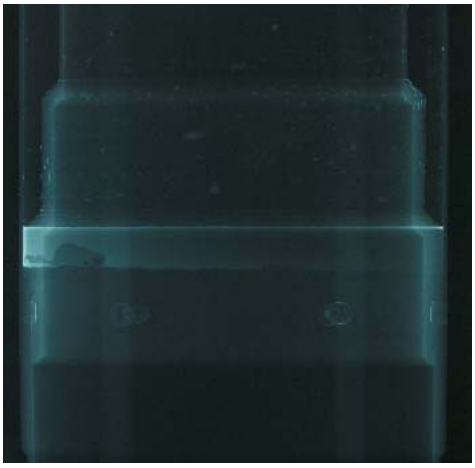

Figure 3. An example of the NR Inspection of the In-Pool Components having Cavities

3. Conclusion

In this paper, the experience of a bubble rise in the reactor pool of HANARO was described with the counter measures taken to minimize the chance of a bubble rise in the reactor pool. The counter measure are working well and the chances of seeing air bubbles in the HANARO reactor pool have reduced. The bottom of the reactor core structure is flat, which can be seen in Fig. 1. This geometry is believed to work as a place where the air bubbles can conglomerate once they exist. This factor should be considered in the design of a pool type research reactor

REFERENCES

[1] I.C. Lim, et al., The Residual Heat Removal System of KMRR and Flap Valve Design, presented at the 3rd IGORR meeting, Sept. 30, 1993, Tokai, Japan.
[2] I.C. Lim, et al., Application of Neutron Radiography for Researches on HANARO, Key Engineering Materials, Vols.270-273, p.1337, 2004.